TechDataSheet

Naval Facilities Engineering Service Center
Port Hueneme, California 93043-4370

TDS-2047-ENV (Revised) **May 1998**

Permeable Reactive Wall

Remediation of Chlorinated Hydrocarbons in Groundwater

Technical Description

The permeable reactive wall or barrier is an emerging clean-up technology used for treating groundwater contaminated with chlorinated hydrocarbons. This innovative technology uses granulated metals to degrade the chlorinated hydrocarbons to non-toxic and biodegradable byproducts. Groundwater is funneled towards the granulated metal treatment section (gate) by sheet piles or slurry walls installed directly in the path of the migrating plume. Pea gravel can be positioned both upgradient and downgradient of the treatment gate to homogenize the influent and effluent flow. Following is a picture of the gate configuration used in a funnel-and-gate system at Moffett Field.

The most common granulated metal used in the gate is zero-valent iron (Fe^0), which is derived from scrap metal and is free of any valence electrons. An abiotic chemical reaction occurs on the Fe^0 surface, that results in the reductive dehalogenation of the chlorinated hydrocarbons in groundwater to form non-toxic iron, chloride, and hydroxide ions and readily biodegradable, light hydrocarbon chain (C2-C5) compounds (e.g., ethanes, ethenes, etc.). The basic chemical reaction is:

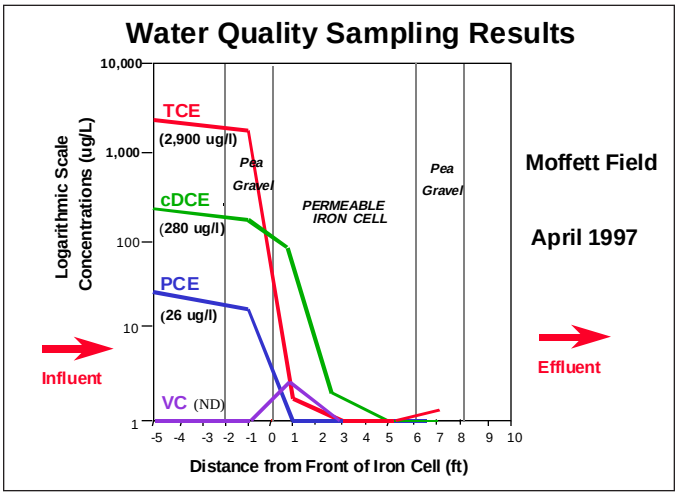
$$Fe^0 + X\text{-}Cl + H_20 \longrightarrow Fe^{2+} + X\text{-}H + Cl^- + OH^-$$

Pilot Study At Moffett Airfield

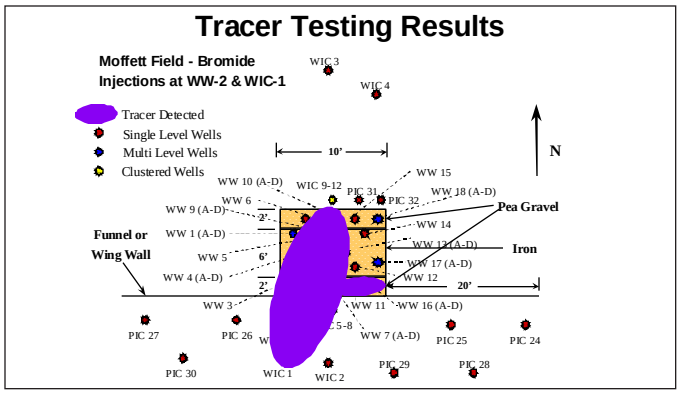
The U. S. Navy Engineering Field Activity West installed a pilot-scale permeable reactive wall at the former Moffett Field site in Mountain View (San Francisco Bay Area), California in April 1996. The Department of Defense (DOD) Environmental Security Technology Certification Program (ESTCP) subsequently sponsored the Naval Facilities Engineering Service Center (NFESC) to validate the performance and cost-effectiveness of the permeable reactive wall technology at Moffett Field for eventual application at DOD sites, as an alternative solution to the costly groundwater pump-and-treat method.

For the past 2 years, the iron reactive wall at Moffett Field has been treating groundwater contaminated with the chlorinated hydrocarbons trichloroethene (TCE), per-chloroethene (PCE), and dichloroethene (DCE). NFESC and contractors, Battelle and Tetra Tech EMI, have been evaluating the performance using various criteria. Quarterly water quality sampling, gaseous analyte testing of reaction byproducts, bromide tracer testing, flow and velocity meter testing, hydraulic capture efficiency measurements, and iron cell coring for analysis of precipitate formation were performed.

The Moffett Field demonstration results show the reactive wall is working as designed. Influent groundwater concentrations of TCE, PCE, and DCE have been reduced to below MCLs or non-detectable limits within the first few feet of the iron cell. Vinyl chloride (VC), which is a degradation byproduct of the dehalogenation process (not detected in the upgradient aquifer), was generated in trace quantities as a result of the reduction reaction. VC was quickly cleaned up within the iron cell.



Reaction byproducts (light hydrocarbons, hydrogen gases, and elevated pH) were detected in the iron cell; however, they rapidly dissipated in the downgradient aquifer. Hydraulic (water level) measurements have indicated the expected groundwater flow capture of the funnel-and-gate system consistent with modeling results. Coring of the iron cell materials indicates the formation of some chemical precipitates, but nothing of any great concern. Velocity meter testing and bromide tracer injection tests have confirmed capture and positive forward flow through the gate at about 1/2 foot/day.



Technology Maturity

There are presently about 15 pilot and full scale permeable reactive wall projects being demonstrated. The EPA has identified reactive walls or barriers as an emerging technology for groundwater cleanup, and has suggested that they can be used at up to 20% of the chlorinated compound contaminated sites. Preliminary cost estimates have shown that permeable reactive walls can be installed at up to 4 times cheaper than groundwater pump-and-treat remediation methods. The interstate technology regulatory cooperation (ITRC) and EPA have published a design guidance document for permeable reactive barriers in September 1997 entitled, "Regulatory Guidance for Permeable Barrier Walls Designed to Remediate Chlorinated Solvents." The design process begins by collecting contaminated groundwater from the site and then performing a bench scale treatability study to determine the reaction half-lives. This treatability information, along with the groundwater flow velocities and transport modeling, is used to determine the residence time required to treat the contaminants. Reactive walls can then be designed to the proper size and installed by using various trenching methods, caisson deployment, clam shell digging, or pressure jetting.

Technology Issues

- Passive in-situ detoxification treatment of groundwater using no external energy source and no aboveground structures.
- Potential to treat chlorinated hydrocarbons and other contaminants to very low or non-detect levels.
- Long-term unattended operation and maintenance; more cost effective than traditional pump-and-treat systems.
- Unknown long-term effects of potential clogging from chemical and/or biological precipitate formation.
- Construction complications from subsurface utilities and/or aboveground structures.

For additional information contact:

Restoration Development Branch, ESC411
(805) 982-4991, DSN: 551-4991

- or -

Technical Application Branch, ESC414
(805) 982-1600, DSN: 551-1600